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NUTRITIONAL STATUS VIS-À-VIS SOIL PHYSICO-CHEMICAL PROPERTIES OF SWEET ORANGE GROWING ORCHARDS OF YSR DISTRICT IN ANDHRA PRADESH

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ABSTRACT

The pH of the soil samples in the study area varied widely, with a mean value of 7.95 and 8.44 at surface and sub-surface soils, respectively. The soils were low in organic carbon at surface and sub-surface and decreased with increasing depth. The electrical conductivity of the soil samples varied from 0.14 to 1.18 dSm^{-1} with mean value of 0.35 dSm^{-1} at 0-30 cm and at 30 to 60 cm depth it ranged from 0.12 to 0.85 dSm^{-1} with a mean value of 0.32 dSm^{-1}. Surface soils recorded high cation exchange capacity (CEC) values than the sub-surface soils. The soils were low in organic carbon and deficit in available nutrients such as Zn, Fe, N, P and Mn. Soil N and Fe had a significant positive correlation with organic carbon (OC). Similarly, Soil K and Ca with CEC, Soil Mg with $CaCO_3$ and Soil sulphur with soil pH had recorded significant positive correlation.

KEYWORDS: Sweet orange, physico-chemical properties, macro and micro nutrients, YSR district

Sweet orange (*Citrus sinensis* (L.) Osbeck) is one of the most important commercial citrus cultivars of India having significant nutritional source (Breeling, 1971) for human health and most of the fruits are consumed as fresh while some portion is used in the form of squashes, juices and drinks. Sweet orange fruits form an essential commercial commodity for several agro-based industries and possess immense economic value. In India, sweet oranges are grown mainly in the states of Maharashtra, Andhra Pradesh, Punjab, Karnataka and parts of North – East region with an area of 2.78 lakh hectares and 45.26 lakh tones (Horticultural Statistics at a Glance, 2015). In Andhra Pradesh, the chief sweet orange production areas are Prakasam, YSR, Ananthapur and SPSR Nellore districts with an area of nearly 0.94 lakh ha and production of 13.16 lakh tonnes during 2014–15 (Horticultural Statistics at a Glance, 2015). In YSR district, area under sweet orange is 0.11 lakh ha with a production of 1.54 lakh Mt (CPO, YSR district, 2015). In YSR district sweet orange is cultivating in a variety of soils ranging from red loamy sands/sandy loams to black clay loams / sandy clay loams. However, the information regarding to their nutrient status in relation to physico-chemical properties is meager, hence the present investigation was taken up.

MATERIALS AND METHODS

To study the nutrient status of the sweet orange grown soils in the YSR district, 50 sweet orange orchards 12 to 13 years old were selected (Fig. 1) in different Mandals during 2014. In each orchard, two separate pits were dug for collecting random and composite soil samples collected at two different depths *viz*., 0 – 30 and 30 – 60 cm with geo reference by considering the location co-ordinates. Collected samples were processed for laboratory analysis.

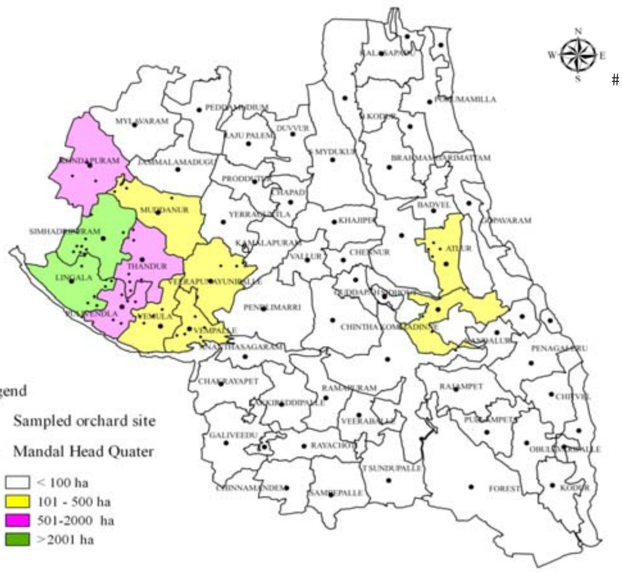

Fig. 1. Map showing area wise distribution of sweet orange and sampled sites in different Mandals of YSR District

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Soil pH was determined in 1:2.5 soil water suspension using digital pH meter (Jackson, 1973). EC was determined in supernatant solution of soil: water suspension (1:2.5) using digital direct read conductivity meter and expressed in dSm^{-1} (Jackson, 1973). CEC was determined by the ammonium acetate displacement method (Bower *et al.,* 1952). The free calcium carbonate content of the soil was determined by treating the soil with a known volume of standard HCl and back titrating the unused acid with standard alkali using bromothymol blue as an indicator (Piper, 1968). Organic carbon was determined according to Walkley and Black wet oxidation (1934).

Available nitrogen in soil was determined by alkaline permanganate method as described by Subbiah and Asija, (1956). Available phosphorus was extracted from soil with 0.5 M sodium bi-carbonate (Olsen *et al*., 1954) and determined by using double beam US-VIS spectrophotometer. The available K was extracted with the neutral normal ammonium acetate and determined by using flame photometer (Jackson, 1973). Calcium and magnesium were determined by versanate titration method (Vogel, 1978), available S was estimated by extracting the soil sample with 0.15 per cent calcium chloride (Williams and Steinbergs, 1959) and S content in the extract was determined by turbidimetric method (Chesnin and Yien, 1951) and available micronutrients viz., iron, manganese, zinc and copper in soil were extracted with 0.005 M DTPA extractant (1 : 2 ratio) developed by Lindsay and Norvell (1978) and contents were estimated by using Atomic Absorption spectrophotometer (Agilent, 200 Series AA).

Results were analyzed in SPSS 20.0 using Pearson correlation coefficient matrix to know the significant variations among the soil physico-chemical properties with mineral nutrients. Range, mean and standard deviation were calculated using Microsoft Excel (Microsoft, WA, USA) spread sheet.

RESULTS AND DISCUSSION

Physico-chemical properties of soil

Soil pH

The pH of the soils samples ranged from 7.53 to 8.62 and 7.62 to 9.20, with average values of 7.95 and 8.44 at 0-30 cm and 30-60 cm depth, respectively (Table -1). The soils of sweet orange orchards in the study area indicated that pH of the surface soil (0-30 cm) was low as compared to that of sub-surface soils (30-60 cm). Similar results were reported by Chetna and Prasad (2011), Yasmin *et al*. (2015) and Surwase *et al*. (2016). The lower pH of surface soil might be due to the presence of more amount of organic matter, and release of organic acids during its decomposition (Reddy and Rao, 1990).

Electrical conductivity (EC)

The electrical conductivity of the soil samples varied from 0.14 to 1.18 dSm^{-1}, with mean value of 0.35 dSm^{-1} at 0-30 cm and at 30 to 60 cm depth and ranged from 0.12 to 0.85 dSm^{-1} respectively. Slightly higher EC levels were observed at surface soils than sub-surface soils, which might be due to irrigating the soil with water having high EC. However, all the orchard soils were non-saline in nature as the mean EC was less than 1.0 dSm^{-1}. The growth of citrus could be adversely affected when EC exceeds 0.5 dSm^{-1}as reported by Kanwar and Randhawa (1961)

Organic carbon (OC)

The organic carbon content of the sweet orange growing soils of the study area ranged from 0.07 to 0.50 per cent in surface (0-30 cm) soils and 0.01 to 0.39 per cent in sub-surface (30-60 cm) soils with average values of 0.34 per cent and 0.21 per cent at surface and sub-surface, respectively (Table-1).

Surface and sub-surface soils in the study area recorded low organic carbon content. Organic carbon content was high in soil samples at 0-30 cm depth than the samples of 30-60 cm depth indicating the organic carbon content decreased with increasing soil depth, which might be due to the additions of organic matter was confined to surface layer in sweet orange growing soils. Similar results were reported by Reddy *et al*. (2013), Yasmin *et al*. (2015) and Surwase *et al*. (2016).

Cation exchange capacity and $CaCO_3$

The cation exchange capacity (CEC) of the surface soils ranged from 24.02 to 64.74 $cmol(p^+)kg^{-1}$, with a mean value of 43.84 $cmol(p^+)kg^{-1}$ and the sub-surface soils varied from 8.74 to 57.69 $cmol(p^+)kg^{-1}$, with mean value of 38.59 $cmol(p^+)kg^{-1}$ (Table-1). Surface soils reported high CEC values than the sub-surface soils, it is an established fact that the cation exchange capacity of soil depends upon the amount and nature of the clay and organic matter

Table 1. Soil physico-chemical properties of the sweet orange growing orchards of the study area

Parameter	Total samples	0 – 30 cm			30 – 60 cm		
		Range	Mean	SD	Range	Mean	SD
pH	50	7.53 - 8.62	7.95	0.29	7.62 - 9.20	8.44	0.42
EC (dSm^{-1})	50	0.14 - 1.18	0.35	0.21	0.12 - 0.85	0.32	0.20
CEC ($cmol(p^{+})kg^{-1}$)	50	24.02 - 64.74	43.84	10.01	8.74 - 57.69	38.59	11.42
$CaCO_3$ (per cent)	50	1.00 - 18.50	5.77	2.96	3.00 - 36.50	13.27	6.13
OC (per cent)	50	0.07 - 0.50	0.34	0.097	0.01 - 0.39	0.21	0.09

Fig. 2. Distribution of $CaCO_3$ in the sweet orange growing soils of the study area

content. Owing to the high organic matter and significant amount of clay content in the surface soil, the CEC recorded higher values than the sub-surface. Similar results were reported by Mohekar (1999) and Yadav and Meena (2009).

The calcium carbonate content of soil showed a variation of 1.00 to 18.50 per cent and 3.00 to 36.50 per cent with mean values of 5.77 per cent and 13.27 per cent in surface and sub-surface soils, respectively (Table 1). About 24 per cent of the surface soils were non-calcareous, 70 per cent were moderately calcareous and 6 per cent were strongly calcareous, but in sub-surface, 6 per cent were non-calcareous, 24 per cent were moderately calcareous and 74 per cent were strongly calcareous (Fig. 2). The content of calcium carbonate was low in surface soil (0-30 cm) than in sub-surface soil (30-60 cm). The increase in calcium carbonate with increase in soil depth was also reported by Prasad *et al.* (2001), Yasmin *et al.* (2015) and Surwase *et al.* (2016). The increase of calcium carbonate content in the lower horizon might be due to calcification, leaching of calcium carbonate and inheritance from parent material.

Available soil nutrient status

Major nutrients (N, P and K)

The available N content ranged from 125.26 to 307.33 kg ha^{-1} at 0-30 cm and at 30 to 60 cm and from 82.72 to 220.69 kg ha^{-1} (Table 2). Available N content was higher in surface horizons and decreased with depth. This variation in N contents might be due to a number of reasons such as difference in natural fertility, variation in cultural practices and N fertilizers application. Moreover, N contents in surface soil was high as compared to the lower depths of soil profiles, which is due to the presence of more organic matter in surface than sub-surface soil. Similar results with regard to soil N was reported by Ranjha *et al.* (2002).

The available P content of soil showed a variation of 5.26 to 39.54 kg ha^{-1} and 2.13 to 25.07 kg ha^{-1} with a mean values of 17.79 kg ha^{-1} and 11.16 kg ha^{-1} in surface and sub-surface soils, respectively (Table 2). However, the highest available P content was observed in the surface horizon and decreased with depth. It might be due to the

Table 2. Soil mineral nutrient content of the sweet orange growing soils of YSR district

Parameter	Total samples	0 – 30 cm			30 – 60 cm		
		Range	Mean	SD	Range	Mean	SD
Available N (kg ha^{-1})	50	125.26- 307.33	224.31	51.05	82.72 - 220.69	150.79	40.04
Available P (kg ha^{-1})	50	5.26 - 39.54	17.79	9.095	2.13 - 25.07	11.16	6.08
Available K (kg ha^{-1})	50	116.14 - 955.92	365.00	169.34	69.66 - 554.51	258.54	95.59
Ex. Ca (cmol(p^{+})kg^{-1})	50	8.50 - 45.25	27.13	8.47	6.00 - 46.50	29.52	8.83
Ex. Mg (cmol(p^{+})kg^{-1})	50	2.25 - 41.50	13.48	8.97	2.75 - 22.50	10.51	4.86
Available S (mg kg^{-1})	50	14.37 - 73.41	30.12	13.19	8.35 - 29.16	16.58	4.51
DTPA-Fe (mg kg^{-1})	50	1.05 - 5.12	2.67	0.92	0.67 - 3.95	1.58	0.72
DTPA-Zn (mg kg^{-1})	50	0.08 - 1.23	0.37	0.25	0.01 - 1.19	0.26	0.20
DTPA-Mn (mg kg^{-1})	50	0.52 - 9.73	4.05	1.98	0.59 - 9.00	2.93	2.03
DTPA-Cu (mg kg^{-1})	50	0.37 - 2.87	1.33	0.53	0.42 - 2.60	0.92	0.41

(Ex. = Exchangeable)

confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external source *i.e.* fertilizers and presence of free iron oxides. The lower available P content in lower horizons compared to upper horizons was due to the fixation (Ranjha *et al*., 2002).

The available K content of the surface soils was differed from 116.14 to 955.92 kg ha^{-1}, with a mean value of 365.00 kg ha^{-1}. In the sub-surface soils of sweet orange orchards in study area, the available K content was varied from 69.66 to 554.51 kg ha^{-1}, with a mean value of 258.54 kg ha^{-1} (Table 2). This might be due to more intense weathering, release of liable K from organic residues, and application of K fertilizers.

As per the ratings given by Muhr *et al*. (1965), out of all the soils of sweet orange orchards studied, 82 per cent were deficit in N and 18 per cent were medium in N, 20 per cent were deficient in P, 60 per cent were medium in P and 20 per cent were high in P, but in case of available K, 32 per cent were in medium range and 68 per cent were in high range (Table 3). Similar results with regard to soil N, P and K was reported by Ranjha *et al*. (2002).

All the available N, P and K were higher in surface soils than sub-surface soils. It might be due to addition of organic manures and fertilizers on surface layers. Similar results were reported by Dhale and Prasad (2009), Allotey *et al*. (2013) and Chaudhari *et al*. (2016).

Secondary nutrients (Ca, Mg and S)

The exchangeable calcium (Ca) content of surface soils was ranged from 8.50 to 45.25 cmol(p^{+})kg^{-1} with a mean value of 27.13 cmol(p^{+})kg^{-1} where in sub-surface soils the exchangeable calcium content ranging from 6.00 to 46.50 cmol(p^{+})kg^{-1} with a mean value of 29.52 cmol(p^{+})kg^{-1} in sweet orange growing soils of the study area (Table 2). The exchangeable calcium in surface and sub surface soils of all the sweet orange growing soils was higher than the critical limit (<1.50 cmol(p^{+})kg^{-1}) as established by Tandon (1989). The presence of sufficient amounts of the exchangeable calcium in soils of sweet orange growing orchards of study area might be attributed to presence of considerable amount of calcium carbonate in soils. The higher exchangeable calcium in sub-surface layer might be due to the accumulation of more amount of calcium carbonate in sub-surface layer as compared to that of surface layers. Higher exchangeable calcium status was reported by many workers in citrus growing soils of Punjab state (Awasthi *et al.,* 1984, Kanwar *et al.,* 1963 and Mann *et al.,* 1979).

Table 3. Distribution of the mineral nutrients in the sweet orange orchards soils of the study area

Parameter	Total samples	Very low		Low		Medium		High		Very high	
		Number of Samples	per cent	Number of Samples	per cent	Number of Samples	per cent	Number of Samples	per cent	Number of Samples	per cent
N (kg ha^{-1})	50	–	–	41	82.00	9	18.00	–	–	–	–
P (kg ha^{-1})	50	–	–	10	20.00	30	60.00	10	20.00	–	–
K (kg ha^{-1})	50	–	–	–	–	16	32.00	34	68.00	–	–
Fe (mg kg^{-1})	50	12	24.00	34	68.00	4	8.00	–	–	–	–
Zn (mg kg^{-1})	50	39	78.00	9	18.00	2	4.00	–	–	–	–
Mn (mg kg^{-1})	50	–	–	4	8.00	19	38.00	18	36.00	9	18.00
Cu (mg kg^{-1})	50	–	–	–	–	9	18.00	41	82.00	–	–

* Soil nutrient indices were referred to the Muhr *et al*. (1965) and Lindsay and Norvell (1978)

Table 4. Pearson correlation coefficient matrix between soil physico-chemical properties

	pH	EC	$CaCO_3$	CEC	OC
N	0.023	0.216	-0.124	0.204	0.716**
P	0.09	-0.017	0.093	0.177	0.104
K	0.099	0.086	0.119	0.383**	0.155
Ca	0.121	-0.155	0.054	0.447**	-0.009
Mg	0.119	0.275	0.346*	-0.046	0.122
S	0.314*	-0.018	0.127	-0.05	0.036
Fe	0.147	0.277	-0.104	0.114	0.279*
Zn	0.068	0.185	0.044	0.069	0.224
Mn	-0.277	-0.252	-0.105	0.105	0.091
Cu	-0.166	-0.206	-0.044	0.152	-0.027

* and ** indicate a significant difference at $P < 0.05$ and $P < 0.01$, respectively.

Similarly, the exchangeable magnesium (Mg) status in all the sweet orange grown soils was higher than the critical limit (<1.0 cmol(p^+)kg^{-1}) as developed by Tandon (1989). The available Mg content of soil varied from 2.25 to 41.50 cmol(p^+)kg^{-1} and 2.75 to 22.50 cmol(p^+)kg^{-1} in surface and sub-surface soils, respectively (Table 1 and Fig. 2). Similar results were reported by Patiram *et al,* (2000) in Mandarin orchards soils of Sikkim and Venkata Subbaiah *et al.* (1982) in citrus growing soils of Anantapur district in Andhra Pradesh.

The available sulphur (S) in surface soils was differed from 14.37 to 73.41 mg ha^{-1} and from 8.35 to 29.16 mg ha^{-1} in surface and sub-surface soils, respectively of sweet orange grown soils of study area (Table 2). The high available S in surface soils than sub-surface soils of the study area might be due to the application of organic manures and sulphur containing fertilizers on surface layers. Similar results were reported by Chaudhari *et al.* (2016).

Micronutrients (Fe, Cu, Mn and Zn)

The available Fe, Zn, Mn and Cu content of surface soils was ranged from 1.05 to 5.12, 0.08 to 1.23, 0.52 to 9.73 and 0.37 to 2.87 mg kg^{-1}, with mean values of 2.67, 0.37, 4.05 and 1.33 mg kg^{-1}, respectively in the sweet orange growing orchards of the study area (Table 2). The available Fe, Zn, Mn and Cu content in the sub-surface soils of study area was varied from 0.67 to 3.95, 0.01 to 1.19, 0.59 to 9.00 and 0.42 to 2.60 mg ha^{-1}, respectively (Table 2).

In general, the available micronutrients under study decreased with increase in soil depth. The decrease in the content of Fe in bottom layers might be due to the increase in pH and calcareousness of the soil, and decrease in organic carbon content, similar results were reported by Diwakar and Singh (1995).

The availability of different micronutrients was studied. From the results, it was observed that 24 and 78 per cent soils were deficit for available Fe and Zn, 68, 18 and 8 per cent of soils were found low in available Fe, Zn and Mn, respectively and 8, 4, 38 and 18 per cent soils were medium in available Fe, Zn, Mn and Cu, respectively. The trend of variation in the available micronutrient contents of soils might be due to variations in organic carbon content and micronutrient containing minerals in soil. Similar variations were reported by Subbaiah *et al.* (1982) for Cu, Fe, Mn status of soils of citrus orchards in Anantapur district and many locations of citrus orchards (Khokhar *et al.* (2012), Noor *et al.* (2013) and Surwase *et al.* (2016).

Correlation between soil physico-chemical characteristics and available nutrients

Simple correlations were worked out between soil physico-chemical characteristics and available nutrients and the correlation coefficients were presented in (Table – 4).

Soil N and Fe had a significant positive correlation with OC (r = 0.716** and r = 0.279*, respectively). Soil K and Ca significantly and positively related with CEC (r = 0.383** and r = 0.447**, respectively). Soil Mg had significant positive correlation with $CaCO_3$ (r = 0.346*). Soil sulphur had a significant positive correlation with soil pH (r = 0.314*).

CONCLUSION

The soil reaction varied widely in the study area and it ranged from mildly alkaline to strongly alkaline, the soils were non-saline in nature as the EC of these soils was far below 4.0 dS m^{-1}. About 24 per cent of the surface soils were non-calcareous, 70 per cent were moderately calcareous and 6 per cent were strongly calcareous. However, in sub-surface soils, 6 per cent were non-calcareous, 24 per cent were moderately calcareous and 74 per cent were strongly calcareous. The soils of the study area were low in organic carbon and deficit in available nutrients such as Zn, Fe, N, P and Mn. Soil N and Fe had a significant positive correlation with OC. Soil K and Ca significantly and positively related with CEC. Soil Mg had significant positive correlation with $CaCO_3$. Soil sulphur had a significant positive correlation with soil pH.

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